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THE MANAGEMENT OF SCIENCE

Seminar held at the Royal Society of Victoria, 7th November, 1984

FOREWORD

The papers presented at this seminar are published with only minor editorial amendment. They are in essence speakers' notes. The decision by the Council of the Royal Society to publish these papers and thus extend the communication of the thoughts in them, is significant. It signals the awareness of Council of the urgent need for scientists to understand the role of the manager and thus be capable of managing science, so that it is more responsive to the economic and social needs of the community. The time is long past when the management of science can be seen as a chore which many scientists grudgingly accept as an interference with a legitimate career.

R. H. Taylor
Assistant Director-General, Department of Agriculture, Victoria
Councillor, Royal Society of Victoria

THE TECHNOLOGIST AS MANAGER FORMULA FOR FAILURE?

By J. G. Onto

Head, Department of Management, David Syme Business School, Chisholm Institute of Technology

Thomas A. Edison never forgot his role as a business man. The profit motive was an essential part of his temperament. Once he said practically to a friend, referring to a newspaper article which discussed him as a scientist, "That's wrong. I am not a scientist. I am an inventor. Faraday was a scientist. He didn't work for money, he hadn't the time. But I do. I measure everything I do by the size of a silver dollar. If it don't come up to that standard, then I know it's no good."

A botanist found a beautiful plant by the wayside. He sat down to analyse it. He pulled it apart and examined every part under a microscope. When he had finished, he could tell the colour of the flower, its classification, and the number of stamens and pistils and petals and bracts, but the life and the beauty and the fragrance had gone.

INTRODUCTION

My purpose in this paper is to get you thinking; to stimulate you to confront the issues relating to the technologist in the management role and act as a catalyst for subsequent discussions which might lead to strategies for better equipping the technologist for the management task. I would like to approach the discussion by posing two hypotheses; an approach which should be empathetic to the *modus operandi* which many of you use in your own occupations.

Hypothesis 1

That technologists are ill equipped by virtue of their training, values and other personality characteristics for the role of management.

Hypothesis 2

That the role of management, in the technological context, is in, and of itself, a precondition for failure in the job.

These hypotheses, supportable or otherwise, would not be worth discussing but for the fact that a large proportion of engineers and scientists, at some stage of their careers, will be in a management role and that proportion is increasing. We don't have statistics for the Australian scene but the US picture indicates that over 70% of engineers are working in jobs with a significant management content by the time they are in their mid-to-late forties. A related point is that, although the technologist manages primarily other technologists, increasingly, there is evidence that he/she will move into the general management role. Again, quoting US experience, it is estimated that in the '80s, more than 50% of chief executives will be holding engineering degrees.

Hypothesis 1

That technologists are ill equipped by virtue of their training, values and other personality characteristics for the role of management.

The training orientation of most technologists focuses heavily on technical subjects. Where they are exposed to other material, they often resent this, seeing it as a digression, or worse still, a soft option, not requiring the same commitment as their main stream studies. An increasing number of applied science and engineering undergraduate programs are incorporating management studies but in most cases, I consider this largely a waste of time.

The motivations for this broadening influence are quite diverse and may include any or all of the following:

1. It's a break from the rigors of the technical studies.
2. The incorporation of management or business studies may make the program more attractive to potential students. This view derives from the observed success and growth of business studies programs.
3. There is someone on the teaching staff who once did a course in administration and would like to teach management.
4. There is someone on the staff who is finding the maintenance of currency in their technological area too difficult and would like to find something apparently less demanding.
5. Last *and* least, incorporation of management-related units is perceived to be educationally desirable. The most material evidence of this motive is the use of management experts from outside the technology faculty to teach the material required.

Having said this, we should be quite clear that management training is required for technologists, particularly those who aspire to management roles. The question is, when? I have some doubts that the undergraduate program is the appropriate place, of course. I do recognise that the undergraduate program heavily emphasises the development of analytical skills. Further, these very skills which will probably determine

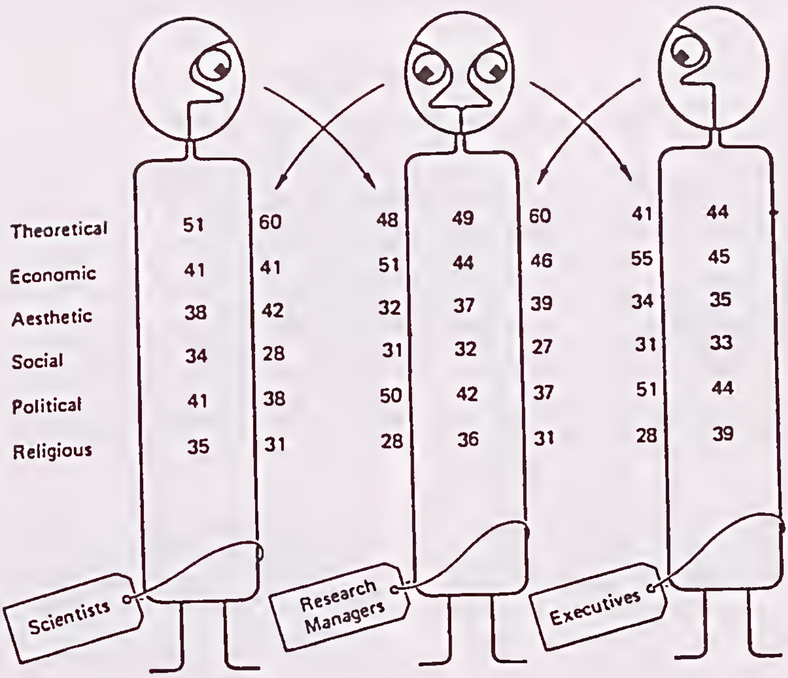

Fig. 1 – Values of Scientists, Research Managers and Executives – Self Ratings Versus Ratings Expected From Others (Guth and Taguiri, 1965)

the success of the technologist, are counterproductive to effectiveness as a manager.

> The training of engineers and scientists typically emphasises the reduction of all problems to terms that can be dealt with by objective measurement and established formulas based on predictable regularities (Badawy, 1982).

Peter Drucker highlighted the dangers of this orientation many years ago. "I am a figures man, and a quantifier, and one of those people to whom figures can talk . . . Reports are very comforting to me; they tell me a great deal. But they have also misled me often enough to make me realise that unless I go out and gain understanding, I may be acting on yesterday, even though the information is up to date."

Turning to personal values, we find considerable support for the view that there are differences in values between those in managerial roles and other organisation members. For the purposes of this discussion, a value is defined as a tendency to prefer certain states of affairs over others. Values may be conceived in a systems framework and one's value system defined as "a relatively permanent perceptual framework which shapes and influences the general nature of an individual's behaviour."

In a landmark study, Guth and Taguiri (1965) studied the values of nearly 1,000 scientists, research managers and executives. Using the Allport, Vernon and Lindzey instrument they measured the values of these groups and the results are summarised in Fig. 1.

Subsequent research has tended to support the view that value systems influence occupational choice and direction. Although the difference in value systems might be interesting, the key question, of course, is, are they relevant? Management has been defined as "getting things done with and through others." The process of management is often described as "planning, organising, directing and controlling resources in order to produce goods and services." We might elaborate the technology managerial role as "planning, organising, directing, and controlling the activities of engineers, scientists, designers etc. to achieve desired goals in technologically related functions."

An increasing amount of research recently has attempted to address the question of management competencies. Without exploring this is any depth, we can, with some confidence say that there is a strong requirement for interpersonal skills, a preparedness to acquire and use power, and an orientation toward the achievement of measurable results and pragmatism. This implies that people who are likely to derive satisfaction from the managerial role are most likely to have consonant value systems. And indeed the research supports this view. Conversely, those with different value

TABLE 1
TECHNICAL MANAGEMENT AND TECHNICAL SPECIALIST—SOME ROLE DIFFERENCES*

Technical Management	Technical Specialist
Counsels, guides, directs people	Is consulted by people
Is sensitive to feelings, attitudes	Is intuitive, creative
Evaluates people's performance	Evaluates data systems or methods
Forecasts, analyzes, controls costs	Technical performance outranks cost
High verbal skill required	High analytical skill required
Transmits and enforces policy	Logic outranks conformity
Directs what methods to use	Determines operational methods
Makes decisions from insufficient data	Seeks additional data
Accepts organizational hierarchy	Accepts heirarchy of truth
Seeks relationships to business goals	Seeks relationships among technical facts

* Source: Balderston, J. L. 1978. Do You Really Want to Be a Manager? *Journal of the Society of Research Administrators* IX, 4.

systems, particularly values usually found in association with technology, are likely to experience frustrations and tensions when called upon to fill a role which requires behaviour which is dissonant with their values.

HYPOTHESIS 2

That the role of management, in the technological context, is in, and of itself, a precondition for failure in the job.

If Hypothesis 1 has any validity, and please remember I am offering hypotheses, not facts, or even theories, then we already have support for this second postulate. I have already suggested that there is an intrinsic conflict between the values typically held by scientists and managers, and their educational orientation. I now want to suggest that this conflict is emphasised by the role prescription of the scientist and manager.

The problem which is enunciated here is not typical to scientists, but is generic to any group of professionals and their managers. Usually, the most competent technician, the best qualified professional, is the most obvious candidate for promotion to the managerial role. Yet, research indicates that this background not only does not prepare the professional for management but may even equip him/her for failure. Most professionals' primary orientation is to their profession. I have known accountants leave their organisation rather than risk their professional standing through association or participation in what they consider to be questionable behaviour of their employer. Scientists who accept promotion to a managerial role experience the same conflict as they realise that their professional standing or currency is threatened by the additional demands and different behaviours imposed on them.

These generalisations need to be tempered according to the level of pragmatism shaping the perceptions of the individual. Thus, the engineer, as an applied sicentist, has more in common with the manager with stronger pragmatic orientations and more similar career objectives. And indeed, as has already been indicated, we do find a high proportion of engineers embarking on managerial careers. Badawy suggests that the "management culture", that is, an amalgam of personality characteristics, management styles, value systems, type of position and management level involved is much more compatible, with the engineering culture than that of the scientist, particularly, the researcher.

As indicated at the outset, the purpose of this paper has been to set a basis for the subsequent discussions, to stimulate thought and to consider the management role in the context of the scientist/technologist. The problems of management for the technologist are quite different than for the typical manager, although similar to those faced by other professional groups. An understanding of these problems can be improved through an exploration of the educational experiences, the value systems, and role expectations of the manager and the scientist, and relating these to the role of the scientist manager (Table 1).

It seems to me, in conclusion, that the consideration of these matters is of importance if we accept that effective management of technological functions is likely to be an emerging area of concern in line with the resource commitment which these functions are attracting.

INDUSTRY EXPECTATIONS OF SCIENCE AND PROBLEMS IN ITS MANAGEMENT

By Bill Briggs

Development Director, Chisholm Institute of Technology

Let me start by specifying the industries to which my comments are relevant and outlining the areas I intend to cover. The industries are the primary and secondary industries, and tertiary industries such as transport and communications which service the other two in the production of wealth. I am aware the economists would include other tertiary industries such as banking, retailing, tourism, entertainment, etc. but I see these as either facilitative of the basic "wealth producers" or of only secondary importance. I include scientific research and the generation of knowledge as wealth producing—if the results are exploited.

I shall treat science as "the systematic organisation of knowledge" and "scientific research" as the application of a particular intellectual process to the generation of new knowledge. It is important to draw the distinction between the scientist trained to generate and organise knowledge and the technologist (for example, the engineer) who is trained to apply knowledge to solve particular problems.

In looking at the expectations industry has of science I shall look at the situation within a particular industry or enterprise and at what industry can reasonably expect of the wider scientific community—including the university. I shall examine some of the problems encountered in making effective use of science, and suggest some solutions.

SCIENCE WITHIN AN INDUSTRY OR ENTERPRISE

Industry employs scientists because it needs their knowledge of a particular discipline, and their trained mind. It looks to science to solve its current problems and, in today's world, to create its new products and businesses. To make an effective contribution to meeting these needs the scientist must have the following attitude:

- imagination, creativity and an ability to spot opportunities;
- an appreciation of the methods of business and the constraints within which it operates;
- an ability to apply science to a wide range of problems; and,
- a knowledge of the process and the barriers to be overcome in bringing a new innovation from conception to profit making.

Time will not permit me to develop the methods of business and the constraints within which it operates in any detail but it is important we understand the essential features. They are:

- all business operates to satisfy a need;
- the enterprise operates in an environment in which it must compete or cease to exist;
- it must generate a satisfactory return on the assets employed; and,
- many constraints are imposed on it by government and by the community at large, e.g., the Trade Practice Acts, occupational health and safety regulations, product liability, etc.

The effective utilisation of science requires skilful and specialist management which must understand science and scientists and the process of translating new knowledge into profits. To use John Onto's definition, the role of that management is:

> "*Planning, organising, directing and controlling the activities of the scientist to achieve the desired goal of the enterprise.*"

The first and hardest task in managing science in an enterprise is to identify scientific goals which are consonant with and will support the overall goals of the enterprise. This may be relatively easy where a scientific team is engaged on process trouble shooting or product improvement but requires considerable vision, imagination, creativeness and an ability to persuade and convince sceptical colleagues or perhaps unimaginative bankers where the work may lead to new products or businesses or render an existing product line or business obsolete.

The second task of the manager of science is to create and maintain the environment in which the scientist can carry out this work. He must be free of the day-to-day distractions of business and have the resources needed for his task but also kept up to date within the goals of the enterprise, developments in the industry, company and government policies, etc.

Finally the manager has to monitor the progress of the scientist's work and make the hard decisions on when a project should be transferred from research to implementation, when it should be terminated or when a whole field of science or research should be abandoned. It is relatively easy to start a research project; it is far harder to kill it. To do so the research manager has to contend with not only the commitment and enthusiasm of the scientific team and their conviction that success is just around the corner, but also with the fact that he may have already spent large sums on the project which will be wasted if it is not successful, the worry that the scientists may be right and success *is* just around the corner, also with the problem that if he does abandon the work he may be left with people he can't employ elsewhere. Successful decision making in this area requires the early and careful definition of the problems to be solved, the setting of progressive goals and the very careful monitoring of progress towards them. If the "problem gap" is not closing, alternative scientific strategies must be devised or the project abandoned.

It is also essential that the scientist and the manager constantly review the relevance of the project to the goals of the enterprise. Very often the manager must rely on the scientist to recognise and advise him of new developments which may make the project redundant, e.g., recognition of the significance of early publications on solid-state electronics made continued work on the vacuum tube irrelevant. Similarly the manager must also look to the market place—there may be no justification for continuing work on a project if the competition has reduced prices below a level at which the costs of further research and development could be recovered.

In employing scientists, industry also hopes that, at a later stage, the intellectual disciplines and training in problem solving which the scientist has received will allow him to make an important contribution to the management and later the direction of the enterprise. John Onto has offered us two hypotheses on the effectiveness of technologists in management. They are:

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May I say that I support the first in full and stress than it applies even more strongly to the scientist than it does to the technologist or engineer. You will see I have reservations about the second. The scientist is trained to think divergently, to generate new ideas and new knowledge and not to accept constraints or convention; the technologist is trained to apply knowledge to the solution of defined problems. That training has already introduced him to some of the pragmatism needed in management. John Onto also referred to the significance of the differing personality traits, educational experiences and value systems of the scientist and the manager and to Balderston's very useful analysis of their role differences which, if may I remind you, are shown in Table 1.

Whilst the scientist or technologist is trained (probably from the mid teens) to handle data and to solve well defined problems (and probably selected these areas because they felt more comfortable dealing with the concepts, quantifiable data, and defined problems of the maths, physics and chemistry than those with the human relations, communication skills and ill-defined problems encountered in the humanities), the problems encountered by the managers and directors of an enterprise are more often than not nebulous, ill-defined, unstructured and have no finite solution; skill in communication is often paramount. Thus the effective utilisation of scientists and technologists in management require not only the identification of those individuals who can make the transition to the management role but training in the skills involved.

The organisation must also ensure that the "Peter Principle" does not operate. That is, it must avoid promoting its best scientist to become an incompetent manager. As the hierarchy and reward structures of business are usually tied to the management structure the successful exploitation of science in industry must also offer a "career ladder" along which the scientist or technologist can progress and gain recognition. Whilst this can parallel the management ladder it is often difficult to cover the full range or to provide the same level of recognition available in the academic world. It can often be helpful to both industry and academia when a relatively free interchange of personnel between the sectors can be achieved.

INDUSTRIES EXPECTATIONS OF THE WIDER SCIENTIFIC COMMUNITY

Whilst industry expects to carry out the applied research needed for its development, it looks to the academic world and the wider research community for both the scientists trained to do that work and for the basic research needed for the generation of new knowledge, new enterprises and new sources of wealth.

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Directs what methods to use	Determines operational methods
Makes decisions from insufficient data	Seeks additional data
Accepts organisational hierarchy	Accepts hierarchy of truth
Seeks relationships to business goals	Seeks relationships among technical facts

Australia's tertiary education system has its roots in the British model and, I believe, that many of our academic research establishments were founded on the 19th century precepts of Oxford and Cambridge. Those precepts were that university research must seek knowledge solely for knowledge sake and that their researchers should be untrammelled by any association with trade or industry. It is worth remembering that the physical sciences were only recognised by Oxford and Cambridge many years after they were well established as disciplines in the German universities and at the Sorbonne and that in both Germany and France academia had, by then, established a close working relationship with industry.

A consequence of that attitude is that even today little attempt is made in English universities to protect intellectual property and that most of the new knowledge they generate is exploited elsewhere. The same has been the tradition and experience in Australia. The Oxbridge attitude is far removed from that at some U.S. universities—notably Stanford, Harvard and M.I.T. There the research scientist, whilst recognising that publication and the free communication of new knowledge is essential to the progress of science, seeks to protect the intellectual property therein and to exploit it for the benefit of their community and themselves. I believe that it is this difference in attitude which accounts for the so productive "science parks" in the Palo Alto, Silicon Valley and Cambridge areas of the U.S., and the absence of such developments in England. It also accounts for the international supremacy of the German chemical industry between say 1860 and 1945.

Whilst no one can question the success of Australian Universities in producing world class scientists and making a better than average contribution to the general growth of knowledge it is also true that only a small proportion of that work makes a direct contribution to the wealth of this nation. In today's highly competitive world in which basic research in other countries is either oriented to national goals, as in Japan and the eastern block, or serves communities with very large markets in which every strand of the work can be exploited through their traditional close relationship between academia and industry (U.S. and Europe), Australia can no longer afford the luxury of its present policies under which some 80% of our research is solely for the pursuit of knowledge and is unlikely to make any contribution to Australia's wealth. It is, I think, a reasonable expectation of industry and of the community at large, which carries the cost of such work, that more of the basic research carried out in our universities be directed towards areas in which there is, at least, some reasonable, long-term prospect that the knowledge generated will be exploited by an Australian industry.

It is also reasonable to expect that the system should produce scientists who actively seek opportunities to exploit the knowledge they generate rather than being satisfied with the kudos they receive from publication. The U.S. experience suggests that these goals of pursuit of knowledge—free exchange and publication and exploiting the results are not incompatible and that the change in attitude required may be relatively small.

I have argued that industry employs scientists because it needs their knowledge and trained minds and that it looks to them to solve its current problems and to create new businesses and new wealth. I suggest that the nation's needs are the same and that the only difference is in the time scale. Similarly I suggest that the process and problems of managing science on a national scale are basically the same as those encountered in industry. Each requires:

- The identification of relevant goals;
- The provision of a climate in which science can flourish;
- The monitoring of progress towards those goals and the adjustment of the work program to achieve them; and,
- The courage to terminate projects which are no longer relevant.

Again the differences lie in the time scale and the magnitude of the task but also in that industry recognises the need for management and attempts to tackle the task—the nation does not.

SUMMARY

Let me attempt to summarise:

- An enterprise, an industry and the nation all need science to survive in today's competitive world.
- To be worthwhile science must be oriented towards goals which support the overall goals of the enterprise or the nation.
- Science must be well managed and directed if these goals are to be achieved and resources used effectively.
- Scientific training predisposes a person *against* effectiveness in management.
- Scientists can, however, be very good managers if the deficiencies of their training are recognised and they are properly selected and trained for the job.

Thank you ladies and gentlemen for your attention and the opportunitiy to express these perhaps iconoclastic views.

GOVERNMENT PERSPECTIVE – WHAT GOVERNMENT EXPECTS OF SCIENCE AND THE FUTURE ROLE OF SCIENCE

By K. Foley

Chairman, Australian Industrial Research and Development Incentives Board

I think that given the excellence of this morning's first session, especially the pertinence of the question period, it would be sensible of me to truncate the remarks that I originally intended to make, to leave as much time as possible for questions. I am able to do that to some extent because of remarks of both the Chairman and John Onto.

There is a great deal of overlap as you might have gathered from people like us on this particular subject, and I intend to talk briefly, hopefully not too briefly so that I miss raising a number of issues which will stimulate questions. I wonder, before I get to my paper, whether I should touch upon or at least provide my views, to give some sort of a background to my philosophy on the scientist/manager dilemma, and put my remarks in both a university and a Government science context.

I would certainly support the view, and I think it came from Philip Law, that once you get into those positions, be you a Vice-Chancellor or be you a Chief Executive, say from CSIRO, the criteria from which you are operating, the criteria on which you should be judged are managerial criteria, your managerial abilities, rather than your scientific abilities. I am looking with interest at what the Universities are doing with regard to their appointment of a Vice-Chancellor. I can quite easily foresee a situation whereby the Chief Executive, say of the CSIRO, or the Vice-Chancellor of the University is not a distinguished scientist and certainly does not practice in his field, whilst he is conducting duties of either the Vice-Chancellor or the Chief Executive of that organisation. It would seem to me that if I wanted a scientist in either of those organisations, I would be rather keen to see someone that was skilled in making sure that the maximum resources that could be obtained for my organisation were attracted to that organisation and they were used in the most effective way possible. I think it is unlikely that someone that is going to be reaching for that file relating to technical matters, all too often bulky, is going to deliver on that dimension, and I think one of the difficulties that one finds in the scientific community, both in the Government and outside is that we have not had a sufficient number of people in the Chief Executive position that are managers, that have had significant managerial skills, that have had their career in the managerial dimension rather than the scientific. Occasionally we find that happy co-incidence where you have an excellent scientist, a person distinguished internationally very often, who can move into a managerial role and perform that excellently and still stay up with his discipline. I would say that that is something of a rarity and one shouldn't be organising situations for that almost unique person.

If I could come now to my topic and by way of a caveat, say that obviously, I cannot give a Government view on science and management. The Minister to whom I report as Chairman of the Industrial Research and Development Board may well be horrified if he thought I was doing that. What I can do and will, is to give the benefit, for what it is worth, of the view from someone that has worked now for almost exactly a year, a year this week in fact, in the Government scientific community; or at least close to the Government scientific community as Chairman of that Board reporting to the Minister for Science and Technology and therefore operating to some extent in that wider Government context of his portfolio; but also very importantly being given the opportunity to relate to the wider scientific community, that is, those scientists that reside in Government, in that quasi-Government area as well as in the universities, and more particularly perhaps, but certainly not exclusively in industry. So I would like to draw on that experience to provide a perspective on the manager and science.

When Bob Taylor asked me to address myself to this topic it struck me that there were two issues that needed to be addressed. They are not mutually exclusive, but I think you can address them to some extent, separately. The first one is the management of science in Government itself, and then the topic that we have been tending to talk most about this morning and that is the management in science. If I can come to a quick summary and then come back to elaborate later on, I would suggest to you that the quality or the level of management in both of those areas is excessively low and that we all suffer significantly as a result of that.

I think it is sensible, not for perhaps a couple of you in this room, but most of you whom I am not familiar with and with whom I have had no contact in the last year, that I make some brief mention about the Industrial Research and Development Board, so that you can understand the platform from which I am generating these views. So I would like to do that, with apologies to a couple of you, for just a few moments before I go on to talk about the management of science by Government, or how Government manages the scarce resources that it provides to Science, and the increasing resources that it is providing to science; secondly coming back to looking at the level of the quality of management in science. The Industrial Research and

Development Board has been in operation since 1976. There has been a scheme much the same as the scheme that is operating now, since 1967. The basis for the scheme, the Board, is to encourage research and development and transfer the benefits of that research and development to the Australian community. It is currently funded in excess of $70 million, so that it provides a significant infusion of funds into the scientific community, perhaps with a couple of very minor exceptions, which I won't go into. It is important for me to point out that those funds go right across the scientific community and we indeed are the only organisation within Barry Jones' portfolio, and possibly in the Federal Government as a whole, that goes right across the scientific spectrum, as I said with possibly a couple of minor aberrations which we are currently trying to correct. Whilst there are a number of components in the scheme, which I won't elaborate on, some two-thirds of the funds go to encouraging research and development and the benefaction of that research and development, through research and development/design projects, so members of the scientific community, whether they be in industry or whether they be in universities or in other research institutes (if they believe that they have a project which they would otherwise not go ahead with, is too expensive, or too risky, or they would not otherwise go ahead with at the appropriate pace), can present that project to the Board, which is a 12 person Board, with members again from across industry and the scientific community, not quite yet from across the country, but with the major States being represented.

The remarks I make about the quality of management will really relate to the material that one sees in the organisations that one visits in pursuit of evaluation of a particular project. Perhaps it is important just to give you a slightly better feel for the organisation to see that the annual limit for funding is $750,000 and they are still talking about those projects. They are funded by and large on a dollar for dollar basis so one is talking about some fairly large projects, that is, about a million and a half dollar project at the top end, and the average is a little less than half that. So we deal with some very, very significant sums of money and to come back to a point that the Chairman was touching on this morning, it is therefore an organisation that most people in this room should know how to interface, and I would suggest to you that most people in this room do not know sufficient about it (which is partly your problem and partly mine but certainly not entirely mine or the Government's), wouldn't know how to effectively interface with it, and as a result of a deficiency in presentation that relates to a large extent to the capacity to manage multi-dimensional and multi-disciplinary projects, perhaps wouldn't be able to be successful in an application before the Board.

Let me now turn to talking about the first issue, and that is the management of science by Government. There are a number of you in this room that have heard me talk about this on a number of other occasions and I put it to you that as I complete my first year in this job, which I should also remind you is only part-time, my greatest concern relates to this point. It isn't my greatest concern that there is not sufficient managerial skills in the scientific community. My greatest concern comes from my observation that there is very, very little focus on the management of scarce resources of the Government which applies to the scientific community. In the industrial domain, particularly, which is the one that we have to concentrate on to a large extent, there is a plethora of organisations which fund the scientific community. They are unco-ordinated, there is little or no co-operation between them. There is no co-ordination and they are not embedded in a policy, in a science policy if you like, in a very broad sense and certainly not embedded in an industrial research and development policy at the more narrow level. So the level of management which is applied to this rather large amount of money is very, very small indeed. In fact, one can say that the whole scheme of things is administered rather than being managed. Perhaps here I should pause and indicate a prejudice that will run through most of my comments, and has been running through my comments as you will have observed thus far. The perspective that I have on the world is a managerial perspective, not an administrative perspective and I will make the comment by way of conclusion I think, that the perspective that has been brought by the scientific community itself and by Government to this domain, has been administrative rather than managerial. But more of that later. I won't elaborate on the difficulties and what I regard as the deficiences that stem from this lack of co-operation and co-ordination and coherence and so forth in the management of science by Government, but I am happy to explore that in as much detail as you would want through questions.

Let me turn now quickly to the second point, management in science and let me do that by talking about my activities on the Board. In the course of a month, I had cause to evaluate privately, and then later in the company of my Board colleagues, with assistance from no doubt very many of you in this room, as referees, some 50-60 quite significant projects relating to research and development, all of them put together by people from the community that we in this room represent. In the course of that month, I would also visit some 10 or 15 firms and speak with members of their research departments, if I am talking about private enterprise, or I would visit a university where, if the university is being far-sighted, I would be able to talk to a research institute that specifically focuses on industry and has a fairly acute understanding of organisations like my own. In some universities that is not possible. They do not organise themselves in such a way that they have concentrated resources that will focus on industry and will focus on Government. It's done on an ad hoc Department by Department, scientist by scientist basis. So, I will go to universities and CSIRO or research institutes and in the course of that go through two situations.

Firstly, one of euphoria when one sees people and the ideas, and the products in many cases, that abound in this country. It really is quite extraordinary and one looks at it and can't believe that the future would be anything other than rosy for this country. There are some extraordinarily talented people in the Australian scientific community. That is the euphoric phase, seeing what the ideas are and what the capacities are in the scientific community, and as I say in many cases, actually seeing the product. The let down comes shortly afterwards when you realise that the idea or that prototype, if you like, or that rudimentary product or the project that relates to all that has to be managed, has to be brought together and people have to operate to a budget, to some sort of planning horizon and so forth. The let down starts when you see otherwise quite fantastic products that are really just not going to go anywhere given the way they are put together and the way that they are described and the way they are "managed". Very often they are managed by a chief scientist, the person that has generated the idea, and his commitment is to the technicalities of the issue rather than managing the entire operation and he will perhaps, very reluctantly, drag himself away from the microscope or whatever it is that he is looking at, to worry about development of funds, marrying together this rather difficult group of people that often speak a different language, that come from different disciplines. I can't recall a project yet that is not multi-dimensional or multi-disciplinary and requires some rather special skills, some managerial skills to bring it all together. So you see these otherwise excellent projects, products, ideas, either not going anywhere, not capable of going anywhere given the way they are structured or which will stagger on perhaps and achieve some 10 or 15 or 20 per cent of their real potential. That in itself is bad enough but the vast majority of products that we look at have to be marketed, not sold, but marketed. There is a pretty fundamental distinction between those two concepts; a distinction that many people in Australian industry have not come to grips with. But when you come to realise that the community will only benefit by those funds being put into the market place and more particularly in many cases going to the international market place, and you look at the marketing skills that are present or proposed to be present, or purported to be present, in those projects, one is really almost totally let down because even if the thing looks as though it is being managed properly, if you can't put it into the market place then you might as well have stayed at home. You will probably have achieved an excellent piece of research and built a rather interesting prototype, probably generated a couple of scientific papers out of it but really in terms of contribution to society you have achieved near enough to nothing and you have achieved that because two components of the exercise have been neglected. You can shrink them into one and talk about management and let's assume that embraces marketing, or you come back into the two as I like to, but the marketing and the managerial side have by and large been neglected. There are very many of us who really don't want to get involved in that anyway. We are much more interested in the scientific aspects of what we are doing but given that the vast majority of funds come from Government research funds, funds that go into the scientific community come from Government and the community. If you really want to sustain your position, and the scientific community is not sustaining its position at the moment, then you have got to, at some stage, convince the community that you can provide them with some benefit as a result of those funds they are expending. I don't think they are expecting that every cent that is spent will produce some exciting product but they are expecting to see some nexus and in very many cases, I think, they do not, which perhaps partly explains why the funds to the scientific community, and most disturbingly the funds to basic research, have shrunk so much.

I discovered the other day that someone was saying to me "well we will just have to start lobbying and get some more funds into pure research" and someone said "well really by lobbying you are not going to get a quantum leap forward, you are only going to make a marginal adjustment" and someone said "well that is probably all that we should be hoping for" but then into the discussion it was intruded the fact that in real terms funds to basic research in the last, I think, 15 years have declined by 40%. So if we want to get back, and they were hardly the healthiest days, if you want to get back to something even approaching that, then you have got to be finding ways that will have you, rather than pecking on the periphery, causing Government and others who contribute funds to make some great leaps forward.

So to try and summarise, there is this quite incredible chasm in this country and it is quite unique in the industrial world. A chasm as deep, as black, as great in this country between what we produce as a scientist by way of research and often up to prototype product stage and what we actually put in the market place. There is no country in the world that does anywhere near as badly as we do. The base from which we operate in this country, as Barry Jones is so often saying, is as good as the base of any other industrial country in the world. It is excellent. The research skills in the country are extraordinary but it's those other steps along the way that we fall down on. One of those steps, or one of those disciplines, one of the sets of skills that is required to allow us to get a better return on that quite remarkable talent is management. It is one that has intruded itself to a very, very limited degree into the scientific community really. But it is, in my view anyway, from that community and our ability to capitalise on what happens in it, that we will derive our future. And, as I say, because we are not doing too well at the management at both the Government level and the scientific community level we are unlikely to get anywhere near the future that we could achieve if we operated ourselves slightly differently.

Mr. Chairman I have spoken longer than I wanted to. Let me just touch on four points which I would like to make by way of summary. The first one is that Government has no coherent policy on the application of science to community benefit and that is certainly true and I would underscore that. I would also underscore for the present, that this Government is turning its mind to this matter in the industrial area, in the industrial application of science. The second summary point that I would make is that management is not, and I would emphasise not, seen by the scientific community or that part of industry that is involved in science, as a separate and distinct skill. I would argue very strenuously that it is and that it takes just as long to come, and to come to a point that John Onto was making this morning, it requires just as much rigour; you do it in a very different way, it takes just as long to acquire, it's just as hard to acquire the skills of management as it is to acquire the skills of any other discipline that I know of. Most of us tend to think if you are good at something else, whatever something else may be, be it an airline pilot or a scientist of any description, then automatically at some stage of your career you can become a good manager. I would suggest to you that is far from the truth. The third point, indeed it is the last summary point that I have written down, is that both Government and the scientific community have been content to administer its resources, which come largely from a process of what I described as disjointed incrementalism, rather than assist in the development of science policy and manage its scarce resources. I haven't elaborated on what I see as the difference between management and administration but I am happy to do that later. So my final point would be this, that unless the scientific community adopts that managerial/policy perspective, gets itself involved with Government and indeed with industry at their policy setting, objective setting level, then the scientific community is doomed to be playing on the periphery, being described as "whimps", as Barry Jones is wont to describe the scientific community, from time to time, and working to wholly inappropriate, very, very frustrating, short and discrete planning horizons. Almost everyone here is in the business of working in a context where the planning horizons are exceedingly long and you need a continuity to be effective within it. If the context within which the Government forces you to work (and there are other contexts I know, but I am talking about the largest and most significant sources of funds) is disjointed, it's discrete and it's incremental, there is, I suggest, a contradiction in those terms.

I suppose the science budget is not much different from most other budgets, and the one that springs to mind is the defence budget which I often argue the current defence budget was possibly set back in the 1940s and all we have been doing with it ever since is making whatever incremental adjustments people could argue, usually in terms of some particular hardware and usually in terms of the replacement of a particular piece of hardware, and not in terms of what it can achieve for the community. So, the science budget has tended to be that way too and what I am arguing is that it will continue to be that way unless the scientific community can intrude itself into the process in a very different way, and that very different way will come from having a management perspective, if you like, on the whole scientific endeavour rather than a narrow, partial and even an ad hoc one. So, what I have finished up saying is that if you are in an environment where the planning horizons are short and discrete and the budgets tend to be established through a mechanism that I have described as disjointed incrementalism, and such a situation presently exists, it isn't in the interests of anyone that it should continue.

Mr. Chairman, thank you very much.

THE MANAGEMENT OF SCIENCE—FUTURE DIRECTIONS AND CHALLENGES. COMMUNITY PERSPECTIVE

By R. H. Taylor

Assistant Director-General, Department of Agriculture, Victoria

Perceptions are very much in the eye of the perceiver and are difficult to quantify. However, it is possible to trace significant changes in community perceptions if one looks back over the period between Hiroshima and Sputnik to the present. To illustrate these changes I have chosen to discuss one small area of science—the use of pesticides—which I believe reflects much of the changing community perceptions to science over this period.

In the 1950s, scientists involved in chemical control of pests and diseases were presented with a large array of extremely effective chemicals as judged by the criterion of rapid destruction of living organisms. Such scientists were seen as positive and productive members of society and fitted the traditional heroic image of scientists which had prevailed for the previous century. By the 1960s, Rachel Carson and others had blown the whistle on DDT but scientists in general failed to perceive the winds of change. They were preoccupied with the development of resistance by target organisms to pesticides but were not paying adequate attention to the growing environmental concern of the community, which incidentally included some of their more perceptive colleagues. In the 1970s, after the turbulent 1960s and in particular the use of crude 245 T in Vietnam, scientists began to realise that, like Vietnam veterans, they were returning from their campaigns as anti-heroes. Even in this climate, scientists persisted with their traditional logical and analytical defence. They argued that if such chemicals as 245 T were used with care, many tests and enquiries have proved them to be safe.

Scientists were bewildered to find that an increasing sector of the public did not accept their logic. Politicians whose jobs depend on judgements of public perception reflected the public disquiet and were much quicker to detect the fears of the public than scientists and they were influenced by a press that was quick to detect what interested the public. The politicians, because of this issue and others, began to query the credibility of scientists. So, scientists have arrived in the 1980s with a belated understanding that they must be accountable for their technologies in a very broad sociological and economic context. It is not that scientists had not heard, but rather that they have regarded their science as being of such value that social issues would somehow sort themselves out to adjust to technological advance.

The question we must now address with urgency is, how can scientists play their part in the introduction of technology in a manner which is acceptable to a community who on one hand embraces it and the other, fears it. The responsibility rests squarely on the managers of scientists who must be prepared to spend time in communication, education and negotiation—skills which are not part of their scientific training and which during the early working years appear to be unproductive and unlikely to bring status or reward. It is now not good enough for scientists to move to management for higher rewards or status with the naive belief that management is common sense and that anyone who thinks analytically and logically will soon encompass it as a vocation.

AN ACADEMIC'S PERCEPTION OF THE INTERACTION OF UNIVERSITIES WITH THOSE WHO "MANAGE" (OR WOULD LIKE TO MANAGE) SCIENTIFIC ACTIVITIES

By NANCY F. MILLIS

Department of Microbiology, University of Melbourne

THE PRIME RESPONSIBILITIES OF UNIVERSITIES

1. *Hand on the state of the art*
   1.1 Basis laws and fundamental knowledge.
   1.2 Expose young scientists to the way in which the scientific method, and experimentation lead to hypotheses and an appreciation that an hypothesis must be testable if it is to be useful.
2. *Advance knowledge*
   2.1 Probe unknown or poorly understood areas—develop new hypotheses; curiosity driven research. To uncover basic principles but to be alert to potential applications.
   2.2 Train scientists in this kind of research—stimulate, encourage novel ideas in young postgraduates.

Because of the long term nature of pay-offs from that work—it is *government* which will pay for this work—it is a national investment. The prime responsibility of universities is to produce graduates who have independence of thought, a heightened imagination, and the technical competence to pursue ideas and to pursue excellence in research, be it fundamental or less fundamental. BUT, there are other responsibilities, some relating quite closely to the management of science.

3. *Dissemination of knowledge/influence in the community*
   3.1 Professional societies—raising awareness of new ideas by presenting papers at conferences, and offering courses to up-date members learning about current problems which arise among practitioners, learning about the needs of professionals.
   3.2 Providing disinterested but informed advice to government on enquiries, standing committees, refereeing grant requests (ARGS, NHMRC), policy decisions (serve on agencies/regulatory agencies/boards). Review the scientific activities of governmental agencies.
   3.3 Public affairs, e.g. ABC, Hospital boards, NATA, National Standards.

Having stated how I see universities as managing science within their own sphere and in the rather wider public arena, does this leave a place for them to interact with industry?

4. *Contact with industry*
   4.1 Universities must remain free to offer the instruction and pursue the research they believe will best advance the science in their particular discipline.

Industry has a right to expect a thinking competent scientist, but they cannot expect scientists trained specifically for their needs. Notwithstanding that view, I do believe it is possible to find many research projects which are of mutual interest to university and industry. Here the benefits flow directly to industry and industry needs to be more prepared to pay than seems to have been the case in the past. Industry/university interactions can take the form of:

   4.2 Consultancies with industry.
   4.3 Joint research projects in the forms of: Funds from industry (contract research), research at university; Staff from industry, research at university; Staff from university, research in industry; Purchase of time and skills on expensive equipment; Problem solving with industry ad hoc and associated with innovation.

What criteria make such work appropriate for a university? It may be undertaken because:

(a) it has a significant element of investigation (along with more routine aspects);
(b) the work funds the purchase of a facility which enables the Department as a whole to benefit, although the work itself may not be highly fundamental;
(c) it provides flexible funds to a research group in return for sharing the rights with the industry to exploit the application of any research findings sponsored by industry;
(d) by providing funds from routine analysis (for example), a Department may be able to employ a technical assistant or buy a better piece of equipment; and,
(e) it allows university and industry to share in the application of research findings.

I believe the benefits from such associations are significant.

Certainly academics can do with an increased awareness of industrial activities. Academics should be aware of the following about industry:

(a) what it would like to do;
(b) what it is doing less well than is possible with the application of current knowledge;
(c) what it might do with ideas, if it (industry) knew they existed; and,
(d) where industry is experiencing problems.

The lack of awareness by industry of the expertise in universities and CAEs is also a real concern, especially in industries where either they don't have a Research and Development Department at all, or it is very small.